HYDROBULL No 5
A TECHNICAL BULLETIN from HYDROGOLD
INT'L WATER MANAGEMENT CONSULTANTS
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MEASURING DISTRIBUTION UNIFORMITY

This article is a practical guide to measuring the Lowest Quartile Distribution Uniformity (LQDU) for sprinklers. For more information on the theory of LQDU and Sprinkler Uniformity, refer to Hydrobull No 4.

Also covered is the importance of setting the sprinkler to grade and how to do it.

Note: The focus is on measuring LQDU for turf. We have not covered measuring LQDU for landscape irrigation of garden beds or the like. Firstly, turf (typically) is the main consumer of water. Secondly, LQDU measurements for garden beds and the like are mostly impractical using the method described here.

1 INTRODUCTION

It is quite simple to measure LQDU. This will indicate whether or not we have a problem with sprinkler uniformity.

However, it may not be so simple to find out what is causing the poor uniformity.

Dry spots resulting from poor Distribution Uniformity.
You know you have a problem. Measuring LQDU enables you to objectively measure it.
LQDU is a tool to demonstrate to management the need for rectification works.

2 HOW TO MEASURE DISTRIBUTION UNIFORMITY

2.1 Catch Cups (Alternatively called Catch Cans)

First we will need "catch cups". These are simply cups to catch the water. These cups are graduated to allow us to measure the water it will catch.

Note: Good quality catch cups are available from the Irrigation Australia Limited web site at http://www.irrigation.org.au

How many? We suggest a minimum of 20. For ease of calculating the LQDU, it is best to use a multiple of 4 (see why on the calculation page following).

2.2 Placement of Catch Cups

Catch cups should be placed in the irrigated area, at least 1 m (3 ft) from any sprinkler. There are no set rules as to how to place them but they should be distributed over the area of interest.

A sample layout for an Australian Rules football field follows:

In any case, ***a sketch of the sprinkler layout and the catch cup placement needs to be made.***

2.3 Wind

All the commercially available performance data for sprinkler nozzles is for zero wind conditions. Therefore, it is normal to conduct catch cup tests in (similar) still wind conditions. This enables a comparison to the theoretically calculated LQDU.

It is also valid to conduct the test in wind conditions as would be typically experienced during the irrigation cycle. However, it would only be comparable to sites under similar conditions.

In any case, ***you need to record the wind speed and direction during the test.***

2.4 Running the Sprinklers

The run-time of the sprinkler should be recorded. Again there are no set rules on how long you run the sprinklers but you do need to record what you do. Typically run the sprinklers long enough for a 5 to (preferably) 10 mm application. For landscape sprinklers this may be (say) 10 minutes; for golf sprinklers (say) 30 minutes.

If all the sprinklers are full-circles, then the run time for all sprinklers (typically) should be the same. If there are part-circle sprinklers, then the run time may need adjusting. Matched precipitation rate sprinklers (only applies to some landscape sprinklers) would run the same time. Rotors (typically) need to account for the arc of operation.

2.5 Measuring the Nozzle Discharge Pressure

The sprinkler nozzle discharge pressure should be measured and recorded.

You may get a bit wet, but you can easily check the discharge pressure at the nozzle with a pitot tube and pressure gauge (see picture to the right). The gauge should be filled with glycerine to absorb vibration. Typically these are available from sprinkler distributors.

2.6 Other Things to Record

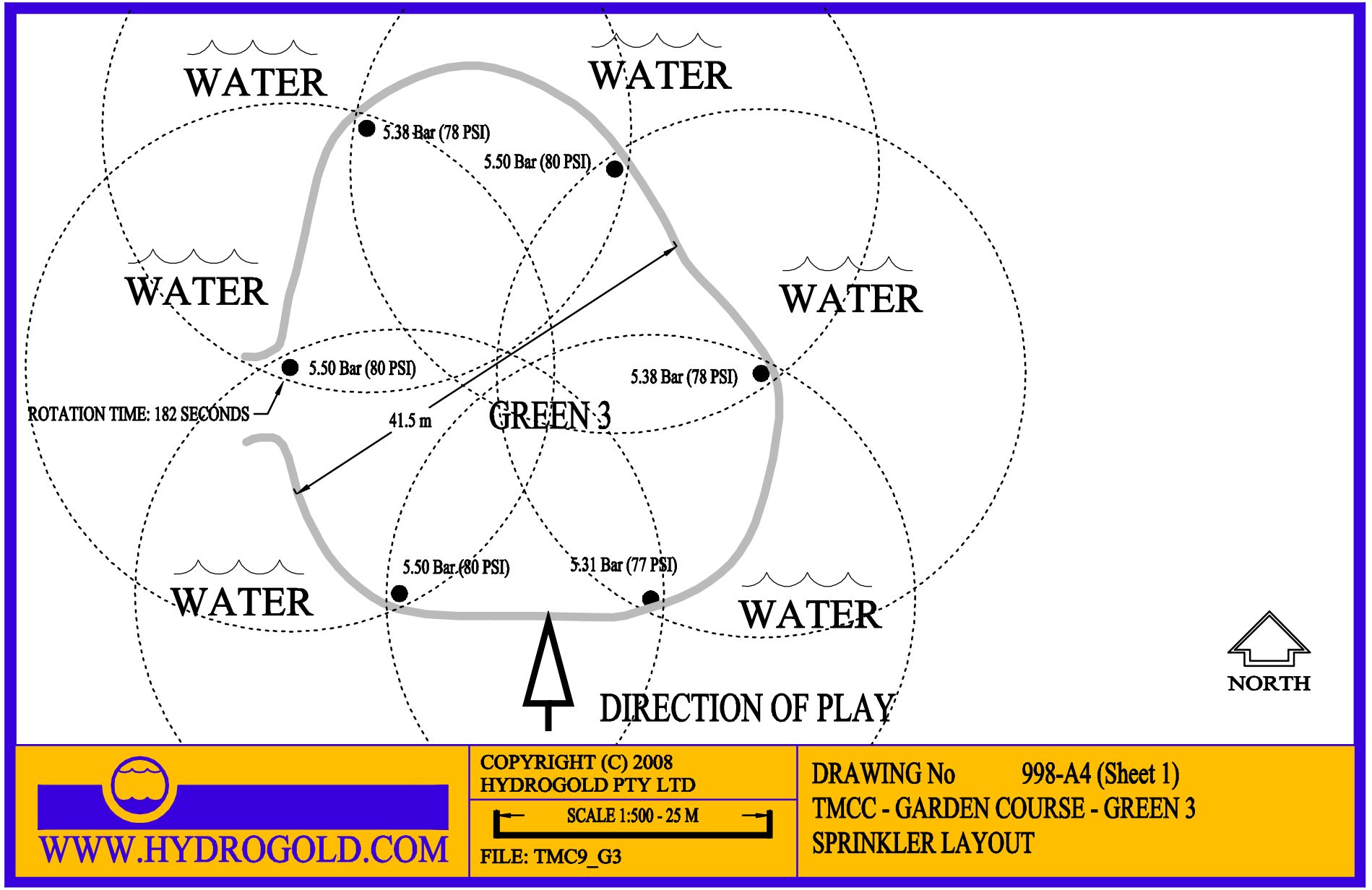
- Almost without saying, there should be no rain!
- Time and Date
- Sprinkler model, nozzle and design pressure
- Rotation times of rotors
- How accurately the sprinklers set to grade
- Controller model, features and condition
- Type of Turf and its Condition
- Soil Type
- Root Zone Depth
- Electrical Conductivity (or Total Dissolved Salts) & pH of Water
- Pressure at Pump Station (or Point of Connection)

3 CASE STUDY - SAMPLE LQDU - DATA COLLECTION AND CALCULATION

3.1 Data Collection

We return to the Tanah Merah Country Club (Singapore) and the 1,750 m^2 No 3 Island Green on the Garden Course (refer to Hydrobull No 4).

The next two sheets show the sprinkler layout (drawing 998-A4 Sheet 1) and the catch cup (can) results (drawing No 998-A4 Sheet 2).



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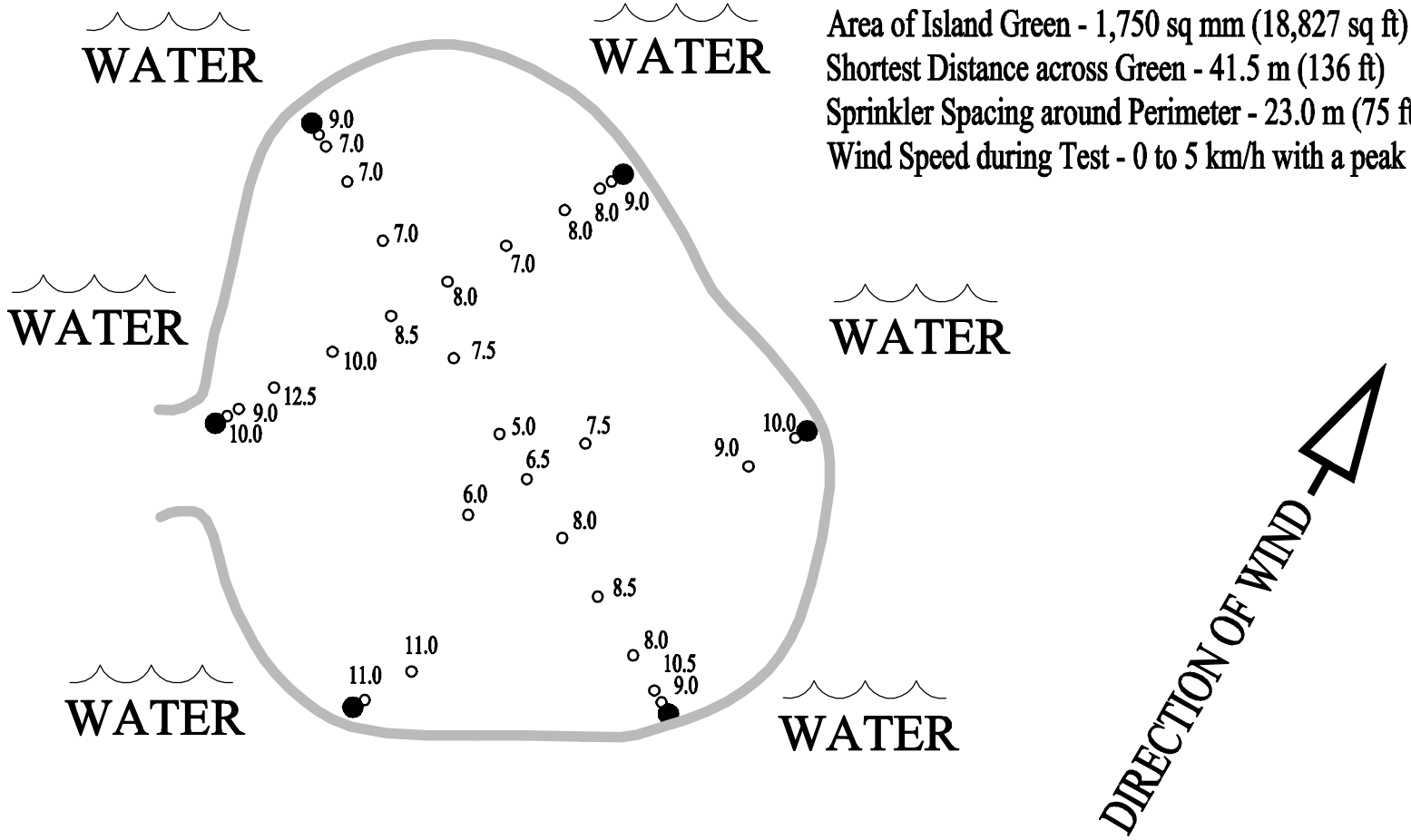
SCALE 1:500 - 25 M

FILE: TMC9_G3

DRAWING No 998-A4 (Sheet 1)

TMCC - GARDEN COURSE - GREEN 3

SPRINKLER LAYOUT



Area of Island Green - 1,750 sq mm (18,827 sq ft)
Shortest Distance across Green - 41.5 m (136 ft)
Sprinkler Spacing around Perimeter - 23.0 m (75 ft)
Wind Speed during Test - 0 to 5 km/h with a peak of 9 km/h

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SCALE 1:500 - 25 M

FILE: TMC9_G3

DRAWING No 998-A4 (Sheet 2)
TMCC - GARDEN COURSE - GREEN 3
CATCH CAN RESULTS IN MM

3.2 The Calculations

From Hydrobull No 4:

The Lower Quartile Distribution Uniformity (LQDU) is defined at the average water applied to the driest 25% of the irrigated area, *divided by* the average water applied to the total irrigated area.

$$\textbf{LQDU} = \frac{\text{Average of Lowest Quarter of Sample}}{\text{Average of Total Sample}} * 100\%$$

As per the following spreadsheet:

$$\textbf{LQDU} = \frac{6.6 \text{ mm}}{8.5 \text{ mm}} * 100\% \quad = 78\%$$

LQDU CALCULATION	
Catch Cup Reading (mm)	
Lowest Quartile (25%)	5.0
	6.0
	6.5
	7.0
	7.0
	7.0
	7.0
Rest	7.5
	7.5
	8.0
	8.0
	8.0
	8.0
	8.0
	8.5
	8.5
	9.0
	9.0
	9.0
	9.0
	9.0
	10.0
	10.0
	10.0
	10.0
	11.0
	11.0
	12.5
No of Catch Cups	28
Total Collected	237.0
Maximum	12.5
Average	8.5
Median (50th Percentile)	8.3
Minimum	5.0
Average of Lowest Quartile	6.6
Average of All Cups	8.5
LQDU	**78%**

The spreadsheet to the left lists the individual catch cup readings (see previous page) in ***ascending order***.

The lowest quartile (the statisticians way of saying the lowest quarter of the readings) is separated from the rest of the readings. Now perhaps you can see why it is convenient to have the number of catch cups to be a multiple of 4.

Results

The measured LQDU is 78%.

The design LQDU was 83%
(Refer to Hydrobull No 4).

Comments

Why was the measured LQDU not 83% as per the design?

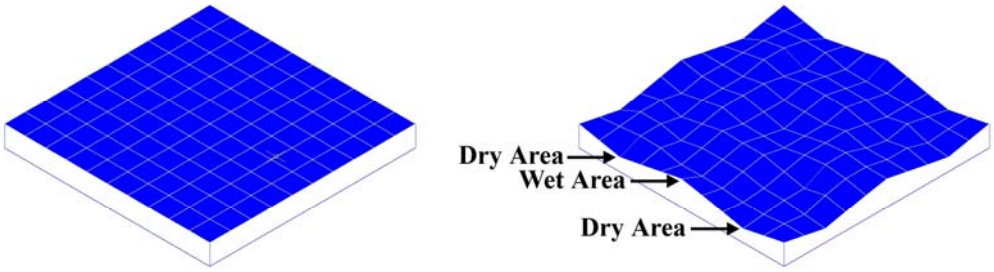
Several factors come into play here. The primary factor is the wind. The design LQDU was 83% assumed zero wind. The measured LQDU was 78% with 0 to 5 km/hr wind (peak of 9 km/hr).

Conclusion

This 1,750 square metre green was difficult to irrigate without placing sprinklers in the middle of it. In consideration of such difficulties, the measured LQDU is a good outcome.

This has been confirmed by observations by Ground Staff who have had minimal hand watering to carry out.

3.3 Interpreting the LQDU



Uniform Irrigation **Non-Uniform Irrigation**

Assuming that the application is perfectly uniform, the volume of water required to irrigate the green daily is calculated as follows:

Volume = 1,750 m^2 *0.006 m = 10.50 m^3

Where:

The Area of the Green is 1,750 m^2

The Desired Application is 6 mm (0.006 m)

Let us review the definition of LQDU:

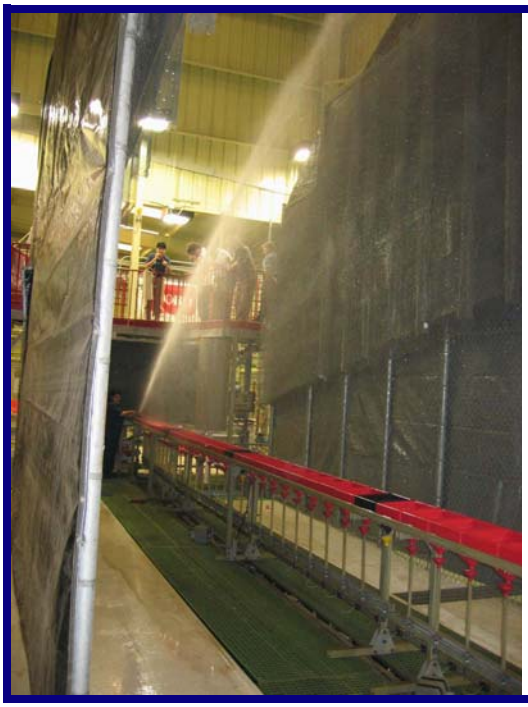
> The Lower Quartile Distribution Uniformity (LQDU) is defined at the average water applied to the driest 25% of the irrigated area, *divided by* the average water applied to the total irrigated area.

With an LQDU of 78% (as calculated previously), the volume is:

$$\text{Volume} = 10.50\ m^3 * \frac{100\%}{78\%} = 13.46\ m^3$$

So, if we want to apply enough water to the driest 25% of the area, then we need to apply and extra 2.96 m^3 (28% more) water.

Not that critical for this special green. But if this was the case over the whole golf course (say 30,000 m^2), there would be a lot of wasted water. Typically we should expect a LQDU of 80 to 90% for a good sprinkler system.



SPRINKLER TESTING

This is the indoor sprinkler testing facility at Toro.

The sprinklers are run and water is collected into the individual red "cans" for automated measuring.

This provides the "single-leg" data for the "PRF" files used for the SPACE program that produces Densograms (refer to Hydrobull No 4).

Note the walls that provide the still wind conditions typical of all commercially available data.

The data reflects the performance of the sprinkler operating under ideal factory conditions without wind. Rely on Hydrogold's experience for translating this data into informed sprinkler choices in the real world with wind and undulating surfaces.

4 SETTING THE SPRINKLER TO GRADE (TURF SURFACE)

This is so often the cause of poor uniformity that it deserves a section of its own.

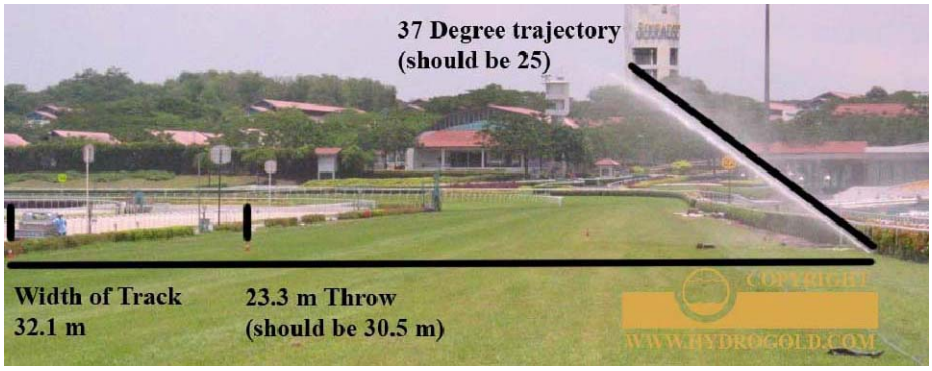
Typically, turf sprinklers should be installed:

4.1 ***Just below grade***, say 5 to 10 mm to avoid mower damage

4.2 ***Parallel to grade*** to avoid mower damage

4.3 ***Parallel to the irrigated area*** for sprinkler uniformity

The example below shows a sprinkler that is not correctly set parallel to the irrigated area by 12 degrees. The nozzle trajectory should be 25 degrees but measures 37 degrees. Consequently the sprinkler throw is significantly shortened and affected by wind.

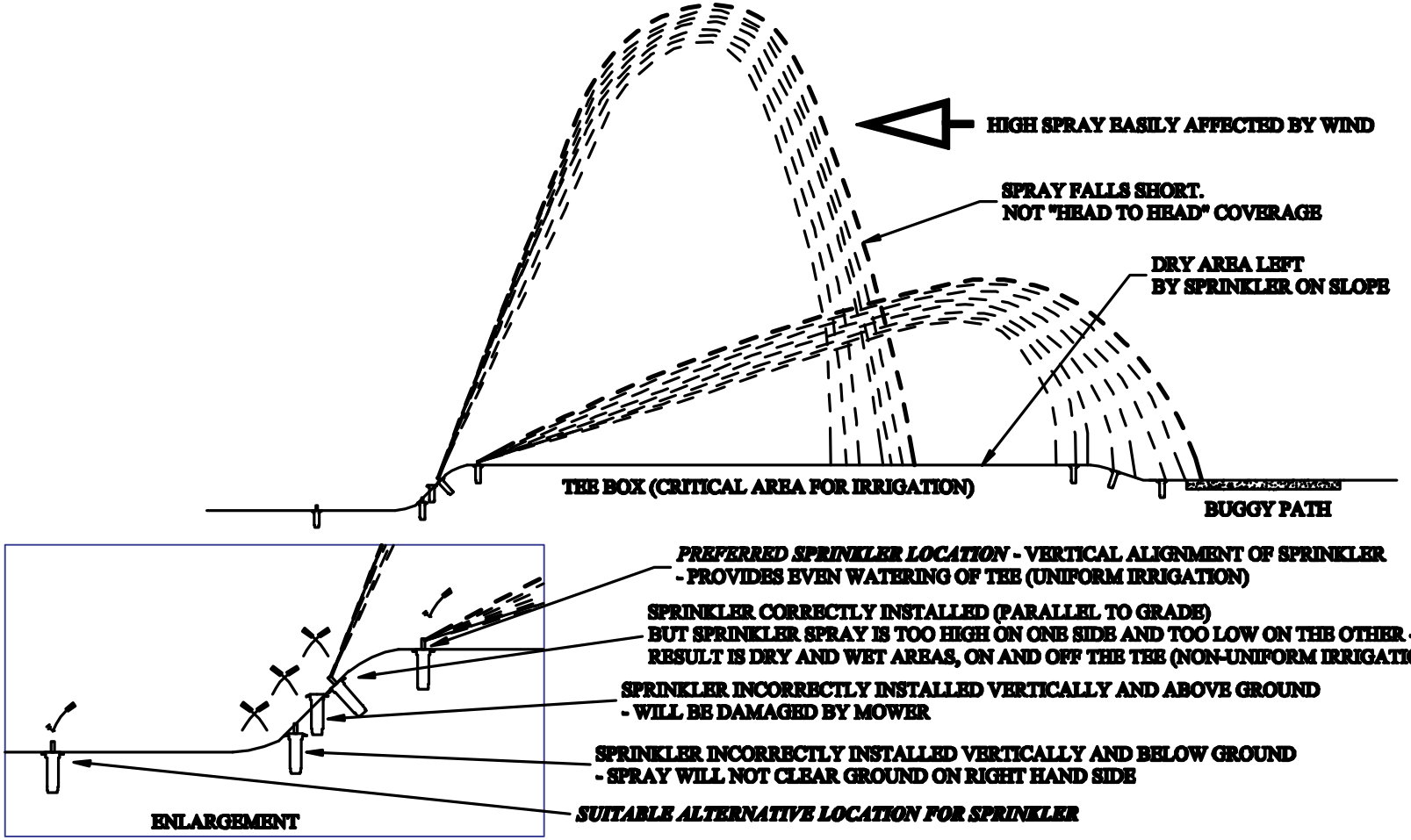


Where ***low angle nozzles*** (say 12 degree trajectory) are used, it is even more critical that sprinklers are accurately set parallel to grade. Being out just 5 degrees means that the nozzle will be 7 degrees on one side and 17 degrees the opposite side.

Where you have undulating surfaces, it can be difficult to have the sprinkler both ***parallel to grade and parallel to the irrigated area***. This is especially so on golf course tees and greens.

This photo shows a golf tee with a sprinkler incorrectly placed on the slope of the tee.

Also refer to drawing No 611-A4 following which shows how it should be done.



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NOT TO SCALE

FILE: SK_GOLF

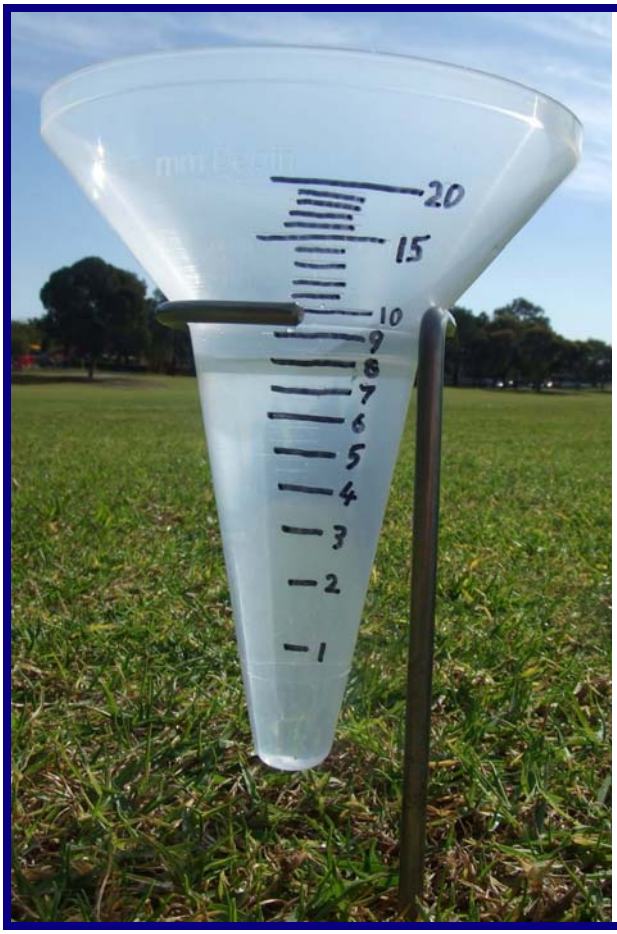
DRAWING No 611-A4
SPRINKLERS ON EMBANKMENTS (PARTICULARLY TEES, ALSO GREENS)

How to Accurately Set a Sprinkler to Grade

One way to accurately set a sprinkler to grade is placing a (straight) piece of 50 mm (2") pipe over the sprinkler as shown below.

Then turn the pipe 90 degrees to ensure that the sprinkler is to grade in that direction also.

The larger the sprinkler, the more important that it is accurately set to grade.



The Catch Cup

Good quality catch cups are available from the Irrigation Australia Limited web site at http://www.irrigation.org.au

These cups increase the ease and accuracy of your measurements.

Note: Hydrogold recommend reading the mm of application rather than the option ml scale (on the reverse side).

Note: The black marks are hand drawn to make the markings visible. The original cup has accurate lines for measuring.

5 OTHER REASONS FOR POOR SPRINKLER UNIFORMITY

Aside from not having the sprinkler set to grade properly, there are several other factors to consider:

5.1 Incorrect, Worn or Damaged Sprinkler Nozzles

Too often the incorrect nozzles are fitted during maintenance. Also, over the years nozzles wear. As well, clearing of nozzles with screwdrivers damages the nozzles.

5.2 Interference to the Water Stream

This should be obvious during operation of the sprinkler.

Even when the sprinklers are installed correctly to grade, problems arise during the maintenance phase of the project.

Overtime, top-dressing, turf growth and machinery traffic can leave the sprinkler too far below grade (the turf surface). See the picture to the left..

Interference often results from the growth of plants, particularly with landscape irrigation (see picture below). We even see landscapers planting in front of sprinklers!

5.3 Sprinkler Spacing

Often the sprinkler spacing is "stretched" during installation by the Contractor (sometimes the Owner) to shrink the budget.

5.4 Insufficient Pressure

Excessively low pressure (say 1.50 Bar or 20 PSI) can (normally) be spotted by eye. However, some field staff see under-pressure sprinklers so often that it is normal to them and therefore they accept it. Normal is not always right.

The nozzle discharge pressure is (typically) 0.15 to 0.20 Bar (2 or 3 PSI) lower than the pressure at the base of the sprinkler. As such, it is a good indicator of there being sufficient pressure (or not).

5.5 Poor Irrigation Design

This takes an experienced Irrigation Consultant to find such an error. The correct sprinkler selection (model, nozzle, operating pressure) is an important part of the design process (Refer to Hydrobull No 4). The best advice is to select an Irrigation Consultant you can trust to design your system in the first place. If not, employ one to troubleshoot (audit) the system.

5.6 Incorrect Rotation Speed (for Rotors, not Sprays!)

This was a significant (but obvious) problem with the old impact sprinklers which relied on good maintenance to ensure a consistent rotation speed.

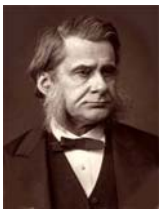
However, with the gear drive sprinklers, the problem could be an incorrect stator being used which is not so obvious.

5.7 Irrigation Scheduling

Typically, the same sprinklers (model, nozzle, operating pressure) on the same spacing need the same run time. However, some adjustments may need to be made to suit actual site conditions. This is one of the advantages of a Valve in Head (VIH) sprinkler system.

6 IN SUMMARY…

Now you can measure the LQDU for your sprinkler system. A good start.



Quote: Thomas Henry Huxley (1825 - 1895) - English Biologist/ Evolutionist

"If a little knowledge is dangerous, where is the man who has so much as to be out of danger?"

Having determined the LQDU, the hard part begins. First you can address the issues noted above. But this may not be as simple as it seems when there is more than one factor at fault.

If need help resolving your sprinkler uniformity problems, our recommendation is to have a professional audit of the irrigation system.

Hydrogold have Certified Irrigation Auditors for Landscape (CIAL) on staff. The CIAL is a certification recognised by the Irrigation Association (USA) and Irrigation Australia Limited. It certifies the person has carried out the necessary level of training to carry out irrigation audits. You also have the backup of Hydrogold's experience on many other projects.